TREMADOC TRILOBITES FROM THE SKIDDAW GROUP IN THE ENGLISH LAKE DISTRICT

by A. W. A. RUSHTON

ABSTRACT. The Tremadoc trilobite fauna from the Skiddaw Group exposed in the river Calder, western Lake District, consists of ten species and is referred to the upper Tremadoc *Angelina sedgwickii* Biozone. Some of the constituent genera are of wide geographical range in outer shelf environments. Two species, *Parabolina expansum* and *Prospectatrix brevior*, are new.

ELLES (1898) studied the graptolite fauna of the Skiddaw Slates Group in northern England and concluded that part of the succession was of Tremadoc age. Subsequent revision did not uphold her claim (Rose 1954; Jackson 1962), and for many years it was believed that the Skiddaw Group was no older than the Arenig Series. Recently, however, Molyneux and Rushton (1985) demonstrated the presence of the Tremadoc Series by means of acritarchs and trilobites collected from a small area in the valley of the river Calder in Cumbria (a locality apparently unknown to Elles). Since that discovery prolonged collecting has added to the number of trilobites found, and the locality has now yielded the richest trilobite fauna (in specimens and species) so far known in the Skiddaw Group, which is as a rule notoriously barren. Detailed examination of the collection confirms the late Tremadoc age of the fauna and indicates a correlation with the *Angelina sedgwickii* Biozone of the Welsh Tremadoc succession and with the *Triarthrus tetragonalis–Shumardia minutula* Biozone or the *Notopeltis orthometopa* Biozone of Argentina. Further investigations have subsequently revealed Tremadoc rocks in other parts of the Lake District: Tremadoc acritarch floras have been found in the Buttermere area (S. G. Molyneux, pers. comm.), and evidence from graptolites and acritarchs demonstrates the presence of Lancefieldian (late Tremadoc?) strata in the Uldale Fells, in the northern Lake District (Rushton 1985).

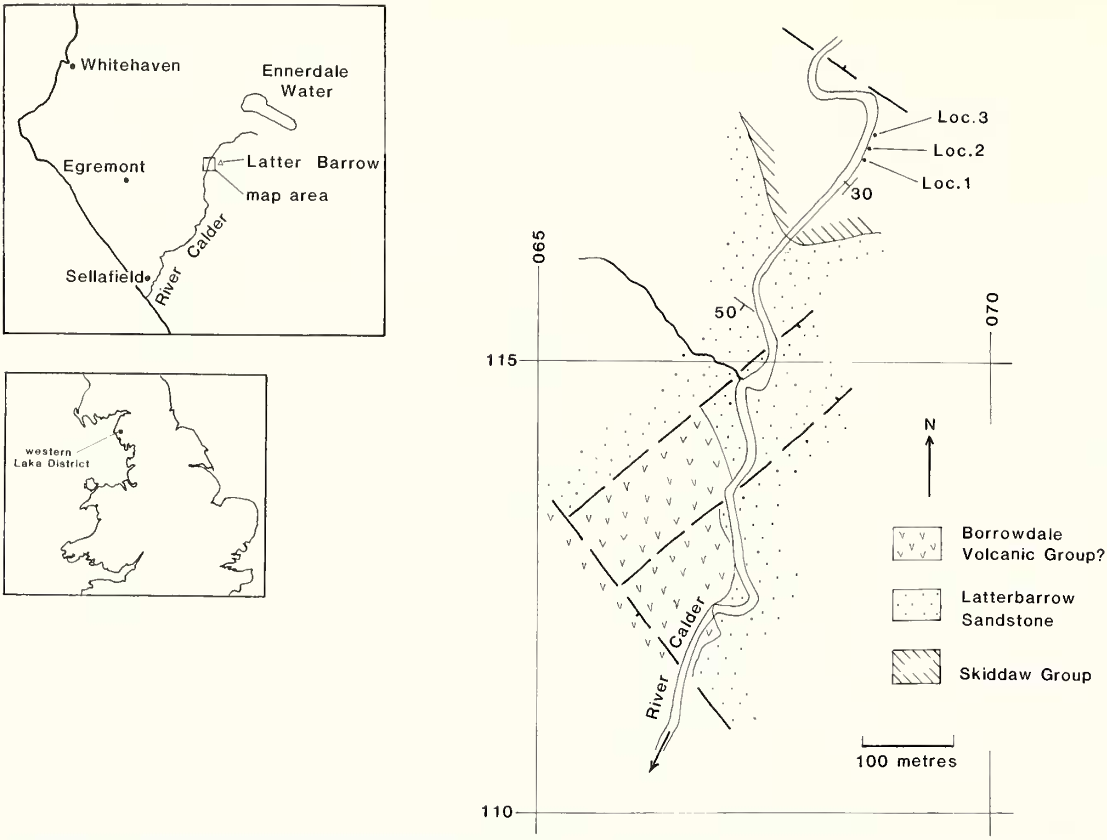
LOCALITIES AND STRATIGRAPHY

The trilobite locality is on the east bank of the river Calder, 1120 m at 297° from the summit of Latter Barrow hill, 6 km east of Egremont, Cumbria (text-fig. 1). At grid reference NY 0687 1178 a meander of the river cuts into the bank and exposes a flat-lying slump fold of Skiddaw Slate. Downstream are grey mudstones, siltstones, and thin beds of sandstone, generally dipping to the west or north-west at 20°–30°. Allen and Cooper (1986) mapped the base of the overlying Latterbarrow Sandstone Formation; it crosses the river 200 m downstream from the meander (Allen and Cooper 1986, figs. 2 and 4).

Shackleton (1975, p. 35) mentioned the discovery of trilobites at this place, but of those specimens the only example I have been able to locate is the '*Cyclopyge*' preserved in the collections of the British Geological Survey (no. GSM 87362). It is an undeterminable fragment of a thorax, and was collected from one of the small outcrops on the west bank of the river.

More recently fossils have been collected at three places on the east bank of the river (text-fig. 1). Locality 1, about 80 m downstream from the meander, yielded *Geragnostus callavei* (Raw *in* Lake, 1906), *Shumardia* (*Conophrys*) sp., *Pareuloma expansum* sp. nov., *Parabolinella triarthroides* Harrington, 1938, *Peltocare olenoides* (Salter, 1866), *Bohemilla* sp., *Niobina davidis* Lake, 1946, Nileid spp. 1 and 2, *Prospectatrix brevior* sp. nov., sponge spicules (cruciform), acrotretid brachiopod indet., gastropod indet. Locality 2, about 15 m upstream from Locality 1, yielded

[Palaeontology, Vol. 31, Part 3, 1988, pp. 677–698, pls. 66–68.]

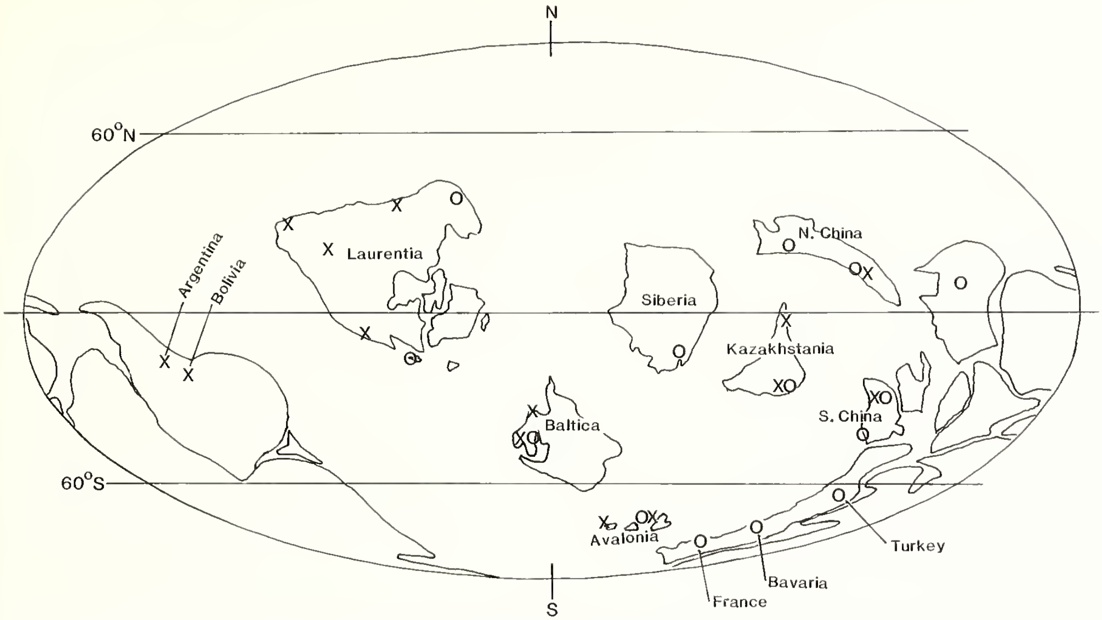


TEXT-FIG. 1. Map to show the fossil localities on the river Calder, western Lake District. Geology from Allen and Cooper (1986). Numbered grid lines relate to National Grid square NY.

Peltocare olenoides, *Prospectatrix brevior*, and acrotretids. Locality 3, about 30 m upstream from Locality 1, yielded *Peltocare olenoides* and acrotretids.

Macrofossils are scarce at the river Calder localities. They have suffered from sedimentary compaction but are only slightly deformed tectonically. Many of the specimens, especially those in fresh rock, are preserved as 'ghosts' (i.e. the rock splits a fraction of a millimetre above or below the bedding-plane with the fossil, as in the case of the thorax of the specimen in Pl. 67, fig. 3); it is at best laborious, and more generally impossible, to develop them. When the mudstone is weathered, preservation may be fairly good. The trilobite remains appear to be exuviae. Many specimens consist of partial exoskeletons such as axial shields (i.e. without free cheeks) and there are few complete specimens that could be construed as dead individuals. One specimen of *P. olenoides* has some of the pleurae shortened, suggestive of a healed injury (Pl. 67, fig. 10; see Owen 1984).

Of the species in the collections from the river Calder, only four are known elsewhere. *N. davidis* occurs in the Upper Tremadoc Penmorfa Beds and Garth Hill Beds in North Wales, and is reported from New Brunswick (see below). The Penmorfa Beds are referred to the *S. pusilla* Biozone and the Garth Hill Beds represent the best development of the *A. sedgwickii* Biozone (Cowie *et al.* 1972). *Parabolinella triarthroides*, as restricted below, occurs in the upper Tremadoc of northern Argentina: it is rare in the *T. tetragonalis–S. minutula* Biozone and common in the *Notopeltis orthometopa* Biozone there (Harrington and Leanza 1957, pp. 28, 107). *Peltocare olenoides* is



TEXT-FIG. 2. A global palaeogeographic reconstruction for the Tremadoc Series (modified from Scotese *et al.* 1979) showing the distribution of *Parabolinella* and *Peltocare* (crosses) and euolomids (rings).

known only from the Garth Hill Beds. If *P. glabrum* is a synonym, the species also occurs in the *T. tetragonalis–S. minutula* Biozone in Argentina but is not known in the *N. orthometopa* Biozone. *G. callavei* is recorded from the *S. pusilla* Biozone in Shropshire and North Wales, but the *Shumardia* (*Conophrys*) is a slightly different form from *S.* (*C.*) *pusilla* that characterizes the *S. pusilla* Biozone in the same areas. The *Pareuloma* and the *Prospectatrix* are new species, and these are of uncertain correlative value.

The Tremadoc age of the fauna is significant as it contributed to Allen and Cooper's (1986, p. 70) interpretation of the unconformable contact at the base of the Latterbarrow Sandstone. Furthermore, the fauna is an example of an outer-shelf or slope trilobite assemblage in the latest Tremadoc. Outer-shelf faunas tend to be rare during periods of world-wide marine regression (Fortey 1984), and the latest Tremadoc has been interpreted as such a regressive interval.

Taken at generic level the fauna from the river Calder is referable to the Ceratopygid Province of Whittington and Hughes (1974). All the genera present are assigned to families (for example, Asaphidae, Cyclopygidae) typical of the Province, though *Parabolinella*, *Geragnostus*, and *Shumardia* (*Conophrys*) were regarded as cosmopolitan genera. *Parabolinella* is widely distributed in the Ceratopygid Province; *Peltocare*, although less widely distributed, generally occurs at localities where *Parabolinella* is known, an exception being at Digermul in Finnmark (Nikolaisen and Henningsmoen 1985). *Niobina* is recorded from Britain, New Brunswick (see systematic section below), Sweden (Tjernvik 1956), and Argentina (Harrington and Leanza 1957); *Prospectatrix* is known from Britain, Turkey, and Kazakhstan (see systematic section below). When the occurrences of genera known from the river Calder locality are plotted on a palaeogeographic reconstruction, they are seen to lie on the margins of cratonic areas from the circum-equatorial belt to near the Antarctic circle (text-fig. 2), though *Parabolinella* may occur as a rarity in shallow shelf deposits (e.g. Winston and Nicholls 1967, p. 76). The distribution somewhat resembles that of the lower Ordovician Isograptid biofacies shown by Fortey and Cocks (1986, fig. 3). Therefore, if one adapts the interpretation offered by Fortey and Owens (1978, p. 239), the Ceratopygid Province seems better regarded as an outer-shelf benthic association, inhabiting cool water over a wide latitudinal range (Cocks and Fortey 1982), rather than a geographically defined province.

SYSTEMATIC PALAEONTOLOGY

The terminology used generally follows that of Henningsmoen (1957). The glabella excludes the occipital ring and the glabellar lobes and furrows are labelled L1, L2 . . . and S1, S2 . . . forwards from the back. All the new material is in the Type and Stratigraphical Collection of the British Geological Survey, Keyworth, Nottinghamshire, UK (specimen numbers prefixed by GSM and RX).

Family METAGNOSTIDAE Jaekel, 1909
Subfamily METAGNOSTINAE Jaekel, 1909
Genus GERAGNOSTUS Howell, 1935

Type species. By original designation, *Agnostus sidenbladhi* Linnarsson (see Tjernvik 1956, p. 188). Fortey (1980, p. 24) discussed the applicability of the family name Metagnostidae.

Geragnostus callavei (Raw *in* Lake, 1906)

Plate 66, figs. 1, 2, 4, 5, 11

1906 *Agnostus callavei* Raw MS *in* Lake, p. 25, pl. 2, fig. 20.

Material. Four exoskeletons, one cephalon, and three pygidia, mostly in counterpart (RX 318–328, 1523–1524A, B). All are from river Calder, Loc. 1.

Description. All cephala poorly preserved. Glabella about one-third of cephalic width, bluntly pointed in front. Furrow marking off anterior lobe faint, form uncertain. Elongate median node immediately behind position of this furrow. Cephalic border furrow wide, border rather flat. Thorax of usual agnostid type.

Pygidial axis occupies two-thirds of length of pygidium and two-fifths of its width. Two anterior lobes of axis (M1 + M2 of Robison 1982, p. 134) together only little more than half as long as posteroaxis. M2 slightly longer than and less wide than M1. Elongate median node extends along M1 and M2 and appears to be divided by transverse furrow. Posteroaxis rounded behind, with small terminal node. Pleural regions subequal in width beside and behind axis. Border furrow broad and shallow; border flat with pair of small posterolateral marginal spines.

Discussion. In 1985 I recorded this species as *Micragnostus* (Molyneux and Rushton 1985) but the discovery of better specimens (e.g. Pl. 66, figs. 1 and 2) showed that the cephalic border, and probably the glabella also, are unlike those in species of *Micragnostus*, as restricted by Fortey (1980, p. 20). *Geragnostus*, after the exclusion of several species not referable to the genus (Fortey 1980, p. 27), offers better forms for comparison.

EXPLANATION OF PLATE 66

Except where otherwise stated the specimens are from the Upper Tremadoc of the river Calder, Cumbria (see text-fig. 1). All are internal moulds except where indicated, and were whitened before photography.

Figs. 1, 2, 4, 5, 11. *Geragnostus callavei* (Raw *in* Lake, 1906). 1, 2, 5, 11, from Loc. 1; 4, from Shineton Shales, *pusilla* Zone, Sheinton Brook, Shropshire (NGR SJ 608 037). 1 and 2, latex cast of external mould (RX 1524A) and counterpart (RX 1523A). 4, GSM 48670, lectotype. 5, RX 1523B. 11, RX 325. All ×6.

Fig. 3. *Geragnostus* sp. Loc. 1. RX 2549, with longer M1 + M2 lobes on the pygidial axis, ×6.

Figs. 6–10. *Shumardia* (*Conophrys*) sp. All from Loc. 1. 6 and 7, RX 292 and RX 920, latex casts of cranidia. 8, RX 1548, internal mould. 9 and 10, RX 921 and RX 922, fragmentary thorax and pygidium; latex cast of external mould and counterpart. All approx. ×16.

Figs. 12–15. *Pareuloma expansum* sp. nov. All from Loc. 1. 12 and 15, RX 1543A and 1543B, small cranidium, with latex cast of counterpart, both ×8. 13, RX 1546, holotype, ×3. 14, RX 520, damaged specimen, but shows fragmentary free cheek and pygidium (see text-fig. 4A), ×3.

RUSHTON, *Geragnostus*, *Shumardia* (*Conophrys*), *Pareuloma*

The species from the river Calder is distinguishable from most other species of *Geragnostus* by the relative shortness of M1+M2 compared with the posteroaxis, and in this feature is most similar to *G. callavei*, from the upper Tremadoc *S. pusilla* Biozone of the Shineton Shales. The pygidium is identical in detail, even to the presence of a terminal node which, though not seen in Lake's original figure, is present on the lectotype (selected Morris 1988, refigured here on Pl. 66, fig. 4). The cephalon of the river Calder specimen appears to differ from that of the lectotype of *G. callavei* only in having a more pointed glabellar front.

Another species in which M1+M2 is relatively short (though not as short as in *G. callavei*) is *G. mediterraneus* Howell, 1935, from the Arenig of the Montagne Noire (figured by Dean 1966, pl. 2, fig. 8, and Capera *et al.* 1978, pl. 5, fig. 4), but that species differs also in having a relatively wider axis. Some specimens of *G. nesossii* Harrington and Leanza (1957, p. 65, figs. 9.2 and 9.5), from lower Tremadoc strata in Argentina, have a glabella shape like that of the specimens from the river Calder, but in *G. nesossii* the pygidial axis is relatively short and M1+M2 form a greater proportion of the axis. In *G. sidenbladhi* M1+M2 are together more than half as long as the posteroaxis and M2 is considerably longer than M1 (Tjernvik 1956, pl. 1, fig. 6). One specimen from the river Calder locality, collected and kindly donated by Mr M. J. N. Cullen (Pl. 66, fig. 3), differs from other specimens from the same locality but resembles *G. sidenbladhi* in having M1+M2 about two-thirds as long as the posteroaxis. Although the pygidium resembles that of *G. sidenbladhi*, the cephalon does not show the relatively narrow cephalic border of that species.

Family SHUMARDIIDAE Lake, 1907
Genus SHUMARDIA Billings, 1862

Type species. Shumardia granulosa Billings, 1862.

Subgenus SHUMARDIA (CONOPHRYS) Callaway, 1877

Type species. Conophrys salopiensis Callaway, 1877, from the Shineton Shales (upper Tremadoc) of Shropshire. This species has long been treated as a junior synonym of *S. pusilla* (Sars) from the Ceratopyge Shale (upper Tremadoc) of Norway, and it may be so; but there has been no revision of *S.* (*C.*) *pusilla* since Stormer's of 1940, and the pygidium in particular is not well known. The synonymy of *pusilla* and *salopiensis* remains therefore 'not yet definitely settled' (Stubblefield 1926, p. 347).

Discussion. Fortey (1980, p. 33) discussed *Shumardia* and listed many species assigned to the genus as conceived in a broad sense. Subsequently Fortey and Owens (1987, p. 119) have argued for the use of subgenera within *Shumardia*, as recognized by combinations of cephalic and pygidial characters. The material considered below has small anterolateral lobes to the glabella, a macropleural thoracic segment, and a transverse pygidium, and is referred to *Shumardia* (*Conophrys*), using Fortey and Owens's criteria.

Shumardia (*Conophrys*) sp.

Plate 66, figs. 6–10

Material. Four cranidia and one pygidium with fragment of thorax in counterpart; two poorly preserved fragmentary individuals (RX 292, 523–524, 921–923, 1547, 1548). All from river Calder, Loc. 1.

Description. Cranidium of typical *Conophrys* form, with bluntly pointed front of glabella outlined by shallow furrow, and sides of glabella defined by deep axial furrows. Anterolateral glabellar ('eye-like') lobes small and faintly delimited, less tumid than those of *S.* (*C.*) *salopiensis*. No basal glabellar (S1) furrows seen.

Only one interpretable thorax preserved, but if macropleural segment assumed to be fourth (as in other species), thorax composed of six segments altogether.

Pygidial axis nearly one-third of width and two-thirds of length of pygidium, and composed of three rings and terminal part. There are two oblique pleural grooves. Border flat and margin entire.

Discussion. The present form differs from most species referred to *S.* (*Conophrys*) because the pygidium lacks a raised marginal rim, such as is well shown by *S.* (*C.*) *salopiensis* (Fortey and

Rushton 1980, figs. 11 and 16). Among those species which lack a raised pygidial rim are three—*S. bottnica* Wiman (1902, pl. 3, figs. 35–38), *S. curta* Stubblefield *in* Stubblefield and Bulman (1927, pl. 4, figs. 4 and 5), and *S. ctenata* Robison and Pantoja-Alor (1968, pl. 99, figs. 19 and 20)—which differ from the river Calder species because the pygidial pleurae curve backwards to become subparallel with the axial line distally and remain separated by the interpleural grooves to the very margin. The present species appears to be more like *S.* (*C.*) *oelandica* Moberg (1900, pl. 14, figs. 4–6) in pygidial features, but the glabella in Moberg's figure is wider in proportion. In that respect the river Calder form is more like the specimen of *S. oelandica* figured by Balashova (1961, pl. 4, fig. 15). In *S.* (*C.*) *oelandica*, however, the thorax has only one segment between the macropleural segment and the pygidium, whereas there appear to be two such segments in the present species. The pygidium of *S.* (*C.*) *liantangensis* Lu and Lin (1984, pl. 6, figs. 15 and 16) is similar to that from the river Calder but differs because it has an additional pygidial segment.

Family EULOMIDAE Kobayashi, 1955

Discussion. The Eulomidae have been discussed by Courtessole and Pillet (1975), Shergold (1980), and Shergold and Sdzuy (1984, p. 80). They are ptychoparioid trilobites showing conservative features such as a conical glabella with simple furrows, distinct ocular ridges, and a well-developed preglabellar field. Distinctive of *Euloma* and several other eulomids are the deep glabellar furrows (S1 and S2) that run into the axial furrows; S1 is strongly oblique inwards and backwards, separating a subtriangular L1 and giving the glabella a calymenid appearance. The palpebral lobe is separated from the ocular ridge by a furrow. Most species have pits in the anterior border furrow (but *Pareuloma impunctatum* Rasetti does not). The pygidium in eulomids is wide and short, composed of few segments, and has a narrow border; the pleural areas have one or two pairs of pleural furrows but the interpleural grooves are faint or absent. None of the above features is especially distinctive, and all could be matched in genera that are not regarded as eulomids. The plesiomorphic nature of the group makes it difficult to diagnose, and this is made more difficult by including in the Eulomidae genera with weak or no glabellar furrows, as has been done in recent years. Yet Apollonov and Chugaeva (1983, text-figs. 3–14; pls. 7 and 8) have demonstrated a morphological gradation between *Ketyna*, some of which have no or only very weak glabellar furrows, and various forms of *Euloma* with deep furrows; although the S1 glabellar furrows in *K. venusta* Apollonov and Chugaeva (1983, pl. 7, figs. 14 and 15) are weak, they are oblique and the species has pits in the anterior border furrow. Shergold and Sdzuy (1984, p. 81) also considered that some eulomid genera might be descended from species of *Ketyna*.

Included genera. Numerous genera have been referred to the Eulomidae. These are listed below, with their type species. (*Euloma*, and names derived from it by the addition of a prefix, are neuter in gender, but some specific names such as *brachymetopa* are nouns in apposition and therefore do not decline. I have treated *abunda* as an invariate arbitrary combination of letters.)

Euloma Angelin, 1854 (type species *E. laeve*, for which see Tjernvik 1956, p. 274).

Pareuloma Rasetti, 1954 (*P. brachymetopa*).

Euloma (*Proteuloma*) Sdzuy, 1958 (*Conocephalites geinitzi* Barrande, for which see Sdzuy 1955).

Eulomina Růžička, 1931 (*Euloma mitratum* Růžička, 1926) appears to have glabellar furrows that do not reach the axial furrow, and is here excluded from the Eulomidae.

Eulomella Kobayashi, 1955 (*E. mckayensis*) has weak and rather transversely directed glabellar furrows, and is probably not a eulomid.

Ketyna Rosova, 1963 (*K. ketiensis*) has weak glabellar furrows but it was placed in the Eulomidae by Apollonov and Chugaeva (1983).

Dolgeuloma Rosova, 1963. In 1963 Rosova described two species, *D. dolganense* (originally *dolganensis*) and *D. abunda*, and designated *D. dolganense* as type species (Rosova 1963, p. 17). In 1968 Rosova (footnote on p. 131) stated that this designation was a mistake and sought to alter the type species to *D. abunda*; but this is inadmissable without resort to the plenary powers of the ICZN. In 1968 Rosova also proposed the Subgenus *D.* (*Pseudoacrocephalites*), with *D. dolganense* as type species. As *D.* (*Pseudoacrocephalites*) is a junior homonym of *Pseudoacrocephalites* Maximova, 1962, Courtessole and Pillet (1975, footnote on p. 253) proposed the replacement name *D.* (*Rosovaspis*). In consequence *Pseudoacrocephalites* Rosova (not Maximova) and *Rosovaspis* are both objective synonyms of *Dolgeuloma* as they all have the same type species. In *Dolgeuloma* the glabellar furrows are weak and do not connect with the axial furrow, and the ocular ridge joins the palpebral lobe without an intervening furrow. These features indicate that *Dolgeuloma* is not to be placed in the Eulomidae.

Lopeuloma Rosova, 1968 (*L. loparense*).

Duplora Shergold, 1972 (*D. clara*).

Euloma (*Lateuloma*) Dean, 1973 (*E.* (*L.*) *latigena*).

E. (*Plecteuloma*) Shergold, 1975 (*E.* (*P.*) *strix*).

E. (*Mioeuloma*) Lu and Qian, 1977 (*E.* (*M.*) *subquadratum*). See Lu and Qian (1983, p. 39), who give differences in proportion that are intended to distinguish *E.* (*M.*) from *E.* (*Proteuloma*). Peng (1984) justifiably regarded these subgenera as synonyms.

E. (*Archaeuloma*) Lee *in* Yin and Lee, 1978 (*E.* (*A.*) *guizhouense*) resembles *Ketyna* except that the palpebral lobe appears to be confluent with the ocular ridge, so it may not be a eulomid.

Iveria Shergold, 1980 (*I. iverensis*).

Karataspis Ergaliev, 1983. The type species, *K. blednovi* Ergaliev (1983, pl. 4, fig. 7) is difficult to interpret, but *K. peculiaris* Apollonov and Chugaeva (1983, pl. 8, figs. 4–9) resembles *Ketyna*.

E. (*Spineuloma*) Lu and Lin, 1984 (*E.* (*S.*) *spinosum*).

Duplora (*Enduplora*) Zhou and Zhang, 1984 (*D.* (*E.*) *ambigua*).

Some of the above taxa, for example *Duplora* and *Iveria*, are characterized by distinctive features, but others depend on such doubtful features as the strength of the glabellar furrows or minor variations in the length or position of the eyes. The presence of pits in the anterior border furrow is a distinctive feature but is not treated as of generic value in, for example, the olenid *Parabolinella*. If the presence of curved and strongly oblique S1 furrows is taken as a unifying feature of the Eulomidae, forms in which this furrow is absent (*Archeuloma*, *Spineuloma*) should not be referred to the family. Among the genera assigned to this restricted view of the Eulomidae, the distinctions between the genera (or subgenera) *Pareuloma*, *Proteuloma*, and *Lateuloma* remain arbitrary, as implied by Dean (1973, p. 300).

Genus PAREULOMA Rasetti, 1954

In *Pareuloma* species the palpebral lobes are small, and the frontal area and pleural regions are broad so that the glabella occupies a correspondingly small proportion of the cranidium. This morphology resembles that of other trilobites of the atheloptic community of Fortey and Owens (1987, p. 105), that they interpreted as inhabitants of outer-shelf or slope environments. The supposed olenid *Plesioparabolina proparia* Harrington and Leanza (1957, p. 87) has a very similar morphology, but I regard the short, pit-like glabellar furrows as evidence that *Plesioparabolina* is neither a eulomid nor an olenid. Its affinities are uncertain.

Pareuloma expansum sp. nov.

Plate 66, figs. 12–15; text-fig. 4A

Name. Latin, expanded, referring to the frontal area.

Material. Holotype cranidium with part of thorax (RX 1546; Pl. 1, fig. 13). Paratypes: a damaged cephalon with fragment of thorax and pygidium (RX 520), a small cranidium (RX 1523A, B), and some other fragmentary specimens (RX 311, 1529, 1538–1540). There are other fragments, and some 'ghosts' (e.g. RX 309, 518) that proved impossible to develop, and these suggest that the species is not rare. All are from the river Calder, Loc. 1.

Diagnosis. *Pareuloma* with small palpebral lobes, anterior border nearly flat, broad, as wide (sag.) as preglabellar field, with pits in the anterior border furrow. Preocular sutures strongly divergent forwards.

Description. Glabella (excluding occipital ring) about as long as wide across L1 (longer in proportion in smaller specimens). Glabellar furrows deep: S1 oblique backwards, S2 similar but shorter, S3 short, indents side of glabella. Occipital ring as wide as base L1, with faint median node. SO composite. Frontal area nearly as long as preoccipital glabella. Preglabellar field slightly inflated in front of glabella. Anterior border broad, flat, at least as long (sag.) as preglabellar field. About sixteen pits lie along anterior border furrow. Palpebral lobes small (about one-tenth as long as cranidium), centred opposite anterior ends of S1. Ocular ridge thin, distinct, oblique. Interocular cheeks about three-quarters as wide as width of glabella across L2. Preocular sutures divergent forwards, making broad inward curve across anterior border. Postocular cheeks about as wide as occipital ring, pleuroccipital furrow curved forwards at its outer end. Postocular sutures oblique, curving back distally.

Free cheeks not well preserved. Hypostome and ventral features not known. Anterior thoracic segments have pleurae wider than the axis. Posterior segments not known. A fragmentary pygidium (Pl. 66, fig. 14; text-fig. 4A) is subtriangular in outline, with border. Axis about one-third of total width but badly preserved. Pleural fields appear to have two pairs of pleural furrows. Surface of convex parts of exoskeleton finely granulose.

Discussion. P. expansum is unusual among eulomids in having an almost flat anterior border, but the small truncate, conical glabella and the small eyes are typical features of *Pareuloma. P. expansum* differs in many details from *P. brachymetopa*, from beds of supposedly Trempealeau (early Tremadoc) age at Cap des Rosiers, Gaspé, and at Broom Point, western Newfoundland. The anterior border is much broader and is practically flat; the arc of pits in the anterior border furrow extends behind a transverse line through the front of the glabella, which is further back than in *P. brachymetopa*. The preglabellar swelling is weaker than in *P. brachymetopa* and the palpebral lobes are a little shorter, judging from Rasetti's reconstruction (1954, text-fig. 2).

P. expansum resembles *P. impunctatum* Rasetti (1954, pl. 61, figs. 1 and 2) in having an expanded and not very convex border, but differs because the border is much broader and is arcuate in plan. The border furrow has well-marked pits, whereas there are none in *P. impunctatum*, and the preocular sutures are strongly divergent forwards. *P. insuetum* Apollonov and Chugaeva (1983, pl. 8, fig. 15) has narrower interocular cheeks and a narrower frontal border. *P. spinosum* Palmer (1968, p. 76, pl. 11, figs. 1–9) differs in having an occipital spine, longer eyes, and a narrower, straighter frontal border.

The arcuate anterior border of *P. expansum* recalls those of *E.* (*Lateuloma*) *latigena* Dean (1973, pl. 3, figs. 5, 6, 8–11) and *E.* (*L.*) *kasachstanicum* Balashova (1961, pl. 4, figs. 11–13), although it differs in being much broader (sag.); the wide interocular cheeks and posteriorly placed eyes are also points of similarity. In *Lateuloma* species the glabella is contracted in front of L2 and is rounded in front, whereas in *Pareuloma* the glabella is truncate and conical. *P. expansum* differs from *Lateuloma* also in having smaller palpebral lobes. The broad, arcuate border and the small eyes distinguish *P. expansum* from all species of *Proteuloma*.

Family OLENIDAE Burmeister, 1843
Subfamily OLENINAE Burmeister, 1843
Genus PARABOLINELLA Brögger, 1882

Type species. Parabolinella limitis Brögger, 1882.

Discussion. The predominantly Tremadoc genus *Parabolinella* is in some respects a conservative member of the Subfamily Oleninae, and retains features of its supposed ancestral stock, for example the well-developed preglabellar field, the position of the eye, and the forms of the postocular cheek, free cheek, and hypostome. However, advanced characters that could be used to characterize *Parabolinella* include: 1, the geniculate and bifurcate S1 furrows; 2, the composite occipital furrow (SO); 3, the accessory lateral glabellar furrow between SO and S1 (seen also in *Hypermecaspis*); 4, the inflated preglabellar field; and 5, pits in the anterior border furrow. Compared with earlier olenine genera there are many thoracic segments and a small pygidium. In the type species, *P. limitis*, features 1 and 2 are well developed, 3 and 4 are faint, and 5 is present (Henningsmoen 1957, pl. 12, figs. 2 and 3). Among other species such as *P. triarthra* (Callaway) and *P. argentinensis* Kobayashi, all the cited features are shown, though the accessory furrow (no. 3) is generally indistinct.

Included species. Henningsmoen (1957, p. 132) reviewed the species of *Parabolinella* then known. Several further species have since been referred to *Parabolinella*:

Moxomia hecuba Walcott, referred to *Parabolinella* by Harrington and Leanza (1957, p. 107).
P. coelatifrons Harrington and Leanza (1957, p. 109) (transferred to *Angelina* by Robison and Pantoja-Alor 1968, p. 787).
P. chilienensis Chang and Fan, 1960.
P? *fortunata* Lazarenko, 1966.
P. prolata Robison and Pantoja-Alor, 1968.
P. tumifrons Robison and Pantoja-Alor, 1968 (referred to *P. hecuba* by Ludvigsen 1982, p. 63).
P. variabilis Robison and Pantoja-Alor, 1968.
P. latilimbata Lu and Chien *in* Yin and Lee, 1978 (see Lu and Qian 1983, p. 49, pl. 6, fig. 2).
P. contracta Lu and Zhou *in* Lu, Zhou and Zhou, 1981.
P. panosa Ludvigsen, 1982.
Remizites bolati Ergaliev, 1983, pl. 3, figs. 12 and 13, is referable to *Parabolinella* as considered here.
P. sayramensis Xiang and Zhang, 1984.
P. lata Xiang and Zhang, 1984 (not *P. lata* Henningsmoen, 1957).
P. jiangnanensis Lu and Lin, 1984.
P. ocellata Lu and Lin, 1984.
P. borohoroensis Xiang and Zhang, 1985 (possibly better referred to *Parabolinites*).
Parabolinella xinjiangensis Xiang and Zhang, 1985.

Some of the above names are likely to be synonyms. *P. contracta* is distinguished by small eyes, ocular ridges that slope outwards and slightly forwards, and postocular cheeks that are as wide as the occipital ring; an accessory glabellar furrow is inserted close to the axial furrow between SO and the geniculate S1, and the surface is finely granulose. Through the kindness of Dr Zhou Zhiyi I have examined latex casts of *P. contracta*, and I consider that the fragmentary *Parabolinella*? figured by Rushton (1982, pl. 3, figs. 23, 24?, 25), from the *Acerocare* Zone, just below the base of the Tremadoc Series as defined in the section at Bryn-llin-fawr in North Wales, is referable to the same species. *P. sayramensis*, from the lower part of the Sayram Formation in north Tianshan (assigned to the lower Tremadoc) seems to be identical with *P. contracta*. *P. lata* Xiang and Zhang (not Henningsmoen) is based on distorted material from the same formation as *P. sayramensis*, but at a different locality. It shows the same features as *P. contracta* and is probably a synonym. *P. ocellata* Lu and Lin, from the basal Tremadoc part of the Yinchupu Formation in Zhejiang is also similar to *P. contracta*, but the ocular ridges do not slope forwards from the eyes. *P. xinjiangensis* differs from *P. contracta* only in the weakness of the accessory glabellar furrow, and may also be a synonym. Finally, *P. bolati* (Ergaliev) resembles *P. contracta* in most features but the figured examples have a proportionally longer preglabellar field.

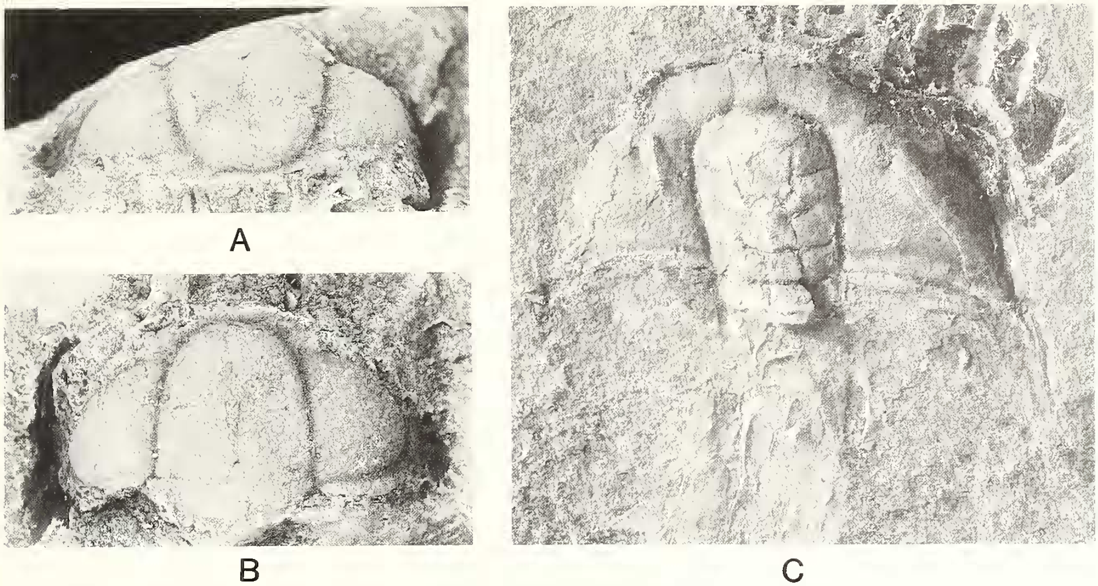
Parabolinella triarthroides Harrington, 1938

Text-fig. 3C

1938 *Parabolinella triarthroides* n. sp., Harrington, p. 194, pl. 7, figs. 10 and 11.
non 1951 *Parabolinella triarthroides* Harrington; Shaw, p. 102, pl. 22, figs. 1–10.
1957 *Parabolinella triarthroides* Harrington; Harrington and Leanza, p. 105, fig. 39.1.
non 1967 *Parabolinella triarthroides* Harrington; Winston and Nicholls, p. 76, pl. 13, fig. 14.

New material. A small cephalon (RX 913–914), a fragmentary free cheek (RX 260), and fragments of thorax (RX 921, 922, 1534, 1535), all from river Calder, Loc. 1.

Description. Cranidium 5·2 mm long. Glabella plus occipital ring three-quarters of cranidial length, subquadrate, widens slightly forwards from occipital ring to L3, anterolateral corners rounded. Occipital ring simple, with small median node. Preoccipital glabella as long as its greatest width. S1 oblique, scarcely geniculate or forked. S2 simple, slightly oblique. S3 faint, S4 not discerned. Preglabellar field somewhat down-sloping, but shows signs of having been originally steeper. Anterior border not well preserved, pits may be present in border furrow, but this is not certain. Preocular sutures slightly divergent forwards. Palpebral lobes small, opposite L3, interocular cheeks about one-third as wide as glabella; ocular ridges extend outwards and slightly forwards. Postocular cheeks a little wider than occipital ring; postocular sutures oblique, slightly sinuous, curving backwards across posterolateral border furrow.



TEXT-FIG. 3. A, B, *Peltocare modestum* Henningsmoen, 1957, BM(NH) It 12903, Ceratopyge Limestone, Bjerkåsholmen, Oslo region (Coll. R. A. Fortey), anterior and dorsal views, ×6. C, *Parabolinella triarthroides* Harrington, 1938, RX 913, river Calder, Loc. 1, ×6.

The thoracic fragments are insufficient for description but indicate specimens of large size, bigger than the large specimen of *P. triarthra* figured by Lake (1913, pl. 7, fig. 4).

Discussion. P. triarthroides, originally described from the upper Tremadoc rocks of Argentina, is based on small cranidia, the figured examples being convex specimens about 3 mm long. Compared with the larger but flattened specimen from the river Calder, the glabellar furrows, the position of the eyes, the width of the fixed cheeks, and the course of the facial sutures are alike. The river Calder specimen is more like Harrington's paratype (1938, pl. 7, fig. 11) than his holotype (fig. 10) in the squarish anterolateral corners of the glabella and the length of the occipital ring.

Shaw (1951, pl. 22, figs. 1–10) referred several specimens from the Gorge Formation of Vermont (a horizon near to or just below the base of the Tremadoc Series) to *P. triarthroides*, since when *P. triarthroides* has been mentioned in discussions of the correlation of the Cambrian–Ordovician (or, rather, the Trempealeauan–Canadian) boundary. However, all Shaw's specimens differ from *P. triarthroides*, for example, in having postocular cheeks that are narrower than the occipital ring (see also Fortey *in* Fortey *et al.* 1982, p. 112, and Harrington and Leanza 1957, p. 107). A fragment figured as *P. triarthroides* by Winston and Nicholls (1967, pl. 13, fig. 14) is also unlike Harrington's type material as the eye is well back opposite L2 and is close to the glabella.

P. lata Henningsmoen (1957, pl. 12, fig. 8) from the upper Tremadoc Ceratopyge Limestone of Røyken, Norway, is very like *P. triarthroides*, but differs in having wider fixed cheeks. *P. limitis*, from the upper Tremadoc Ceratopyge Shale of Norway, has narrower fixed cheeks than *P. triarthroides*, a longer palpebral lobe, and a strongly geniculate S1 (Henningsmoen 1957, pl. 12, figs. 1–3). *P. triarthra* from the Shineton Shales of Shropshire has narrower fixed cheeks than *P. triarthroides* in both large and small specimens (Lake 1913, pl. 7, figs. 4–12); furthermore, the preoccipital glabella tends to be wider than long and S3 is often distinct. The same is true of *P. argentinensis* (Harrington and Leanza 1957, figs. 37 and 38) which is like *P. triarthra* but distinguished by the more widely divergent preocular sutures. *P. latilimbata* Lu and Chien (see Lu and Qian 1983, pl. 6, fig. 2) differs slightly in several respects: the preglabellar field is longer and the fixed cheeks wider than in *P. triarthroides*, the glabellar furrows are deeper, the occipital ring is more strongly composite, and the occipital node is stronger.

Subfamily PELTURINAE Hawle and Corda, 1847
Genus PELTOCARE Henningsmoen, 1957

Type species. Acerocare norvegicum Moberg and Möller, 1898.

Discussion. Henningsmoen (1957) assigned three other species to *Peltocare*, namely *P. olenoides* (Salter), *P. rotundifrons* (Matthew), and *P. glabrum* (Harrington). Since then two further species have been described: *P. modestum* Henningsmoen (1959, p. 158, pl. 1, figs. 9 and 10; text-fig. 3A, B herein), and *P. compactum* Nikolaisen and Henningsmoen (1985, p. 21, figs. 8 and 16A–R). Nikolaisen and Henningsmoen (1985) considered that the specimens described by Robison and Pantoja-Alor (1968, p. 793, pl. 103, figs. 14–23) as *P. norvegicum* represent an independent species. *Alimbetaspis kelleri* Balashova (1961, pl. 3, figs. 15–19) resembles *Peltocare* species, but has larger palpebral lobes and more transverse postocular sutures. Nikolaisen and Henningsmoen (1985, p. 27) treated it as a synonym of *Jujuyaspis.*

Peltocare olenoides (Salter, 1866)

Plate 67; text-fig. 4B

1866 *Conocoryphe olenoides* n. sp., Salter, p. 308, pl. 8, fig. 6.
1919 *Peltura olenoides* (Salter); Lake, p. 100, pl. 12, figs. 4 and 5.
1938 *Cyclognathus glaber* sp. nov., Harrington, p. 212, pl. 9, figs. 1, 5, 12.
1957 *Acrocarina glaber* Harrington; Harrington and Leanza, p. 93, fig. 32.3*a*–*d*.
1957 *Peltocare olenoides* (Salter); Henningsmoen, p. 249.
non 1968 *Peltura olenoides* (Salter); Curtis, pl. 9A.
1985 *Peltocare olenoides* (Salter); Molyneux and Rushton, fig. 1.14.

Type material. Salter's monotype is a distorted cephalon (GSM 10846; Pl. 67, fig. 4) from the Garth Hill Beds (upper Tremadoc Series) of Garth Hill, near Minfordd, North Wales. I here interpret the species by reference to a previously unfigured topotype (BGS Zi 1668, 1669; Pl. 67, figs. 6 and 7). This is smaller than the type but (if correctly referred to *P. olenoides*) gives a much better idea of the species.

New material. Twenty specimens and fragments of cephala, axial shields, and fragments of thorax and pygidium (including RX 279, 302–305, 312, 313, 329, 330, 490, 491, 517, 918, 1530–1534). Most are from Loc. 1; one or two specimens from each of Loc. 2 and 3.

Description. Glabella plus occipital ring nearly parallel-sided, bluntly rounded in front. Glabellar furrows not seen, occipital furrow distinct. Occipital ring less than one-quarter of length of cephalic axis, with faint median node. Palpebral lobes short, inconspicuous, placed well forward such that their anterior ends are nearly in line with anterior end of glabella. Faint ocular ridges seen in one small specimen (Pl. 67, fig. 3). Frontal area about one-tenth of cranidial length, not differentiated into border and preglabellar field. Preocular sutures short. Postocular cheeks about 0·7 times as wide as occipital ring. Postocular sutures long,

---

EXPLANATION OF PLATE 67

Figs. 1–11. *Peltocare olenoides* (Salter, 1866). 1–3, 5, 8–11, all Loc. 1; 4, 6, 7, Upper Tremadoc, Garth Hill, near Minfordd, Gwynedd, North Wales (NGR SH 593 393). 1, RX 1531, latex cast of external mould, ×4. 2, RX 517, cranidium with left free cheek; white pointer indicates position of left eye shown in text-fig. 4B, ×2. 3, RX 312, small cranidium with part of thorax exposed, ×8. 4, GSM 10846, holotype, ×4. 5, RX 297, latex cast of cranidium of specimen figured by Molyneux and Rushton (1985, fig. 1.14), ×4. 6 and 7, BGS Zi 1669 and 1668, internal mould and latex cast of counterpart, both ×4. 8 and 11, RX 330 and 329, internal mould of fragmentary cephalon showing the fixed cheek and latex cast of counterpart prepared so as to show the free cheek, both ×4. 9, RX 303, thorax and pygidium, flattened, ×4. 10, RX 302, part of thorax and pygidium; note terrace lines on the pygidium and the truncated pleurae, ×4.

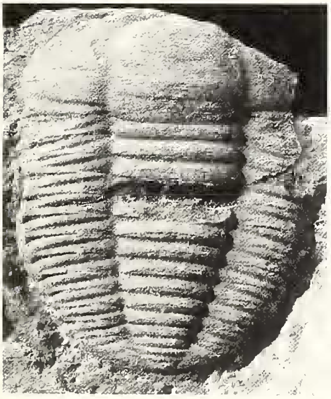
1

2

3

4

5



6

7

8

9

10

11

RUSHTON, *Peltocare*

convexly curved. No sutural ridge seen, except for vestige seen at posterolateral corner of one small cranidium (Pl. 67, fig. 3). Pleuroccipital furrow curved forwards somewhat at its outer end.

Free cheek semicircular in outline, with broad, faint border furrow and narrow border, and no genal spine. Posterior end produced into long pointed process directed adaxially (Pl. 67, fig. 11). Specimen in Plate 67, fig. 2 shows eye with holochroal facets, visible when moistened with alcohol (see text-fig. 4B). Hypostome, known from one indistinct impression (Pl. 67, figs. 8 and 11), of normal pelturoid type.

Thorax of twelve segments. Anterior pleura about two-thirds as wide as axial ring. Thorax widens slightly backwards to fifth segment, behind which it narrows. The last pleura is nearly as wide as axis.

Pygidium more than twice as wide as long. Pleural field as wide as axis. Axis with three rings and terminal part. Pleural fields marked by one or two pleural furrows. Margin entire with narrow border. Dorsal surface of pygidium marked by terrace lines subparallel with posterior margin, as in other pelturines (Pl. 67, fig. 10). Remainder of exoskeleton smooth.

Discussion. As discussed by Henningsmoen (1957), the species of *Peltocare* are all rather similar. *P. compactum* has narrower pleural regions than the other species, and in *P. modestum* (text-fig. 3A, B) the glabella is comparatively sharply rounded in front. *P. rotundifrons* has a smaller number of pygidial axial segments than other species.

Henningsmoen (1957) suggested that *P. glabrum* might be a synonym of *P. norvegicum*. At that time *P. olenoides* was poorly known, but the new material shows that it, too, is very like *P. norvegicum*. I can see nothing to distinguish *P. glabrum* from *P. olenoides*, and accordingly regard it as a synonym; but I hesitate to synonymize *P. norvegicum* because there appear to be slight differences: the pleuroccipital furrow in *P. norvegicum* seems to curve forward more strongly than that of *P. olenoides*; the anterior pleura in *P. norvegicum* appears to be only half as wide as the axial ring, and is thus shorter (tr.) than in *P. olenoides* (note, however, that this observation is based only on Brögger's figure (1882, pl. 1, fig. 4) of an imperfect specimen and on the external mould figured by Henningsmoen (1957, pl. 27, fig. 8) in which the full extent of the pleurae may not be shown).

The specimen that Curtis (1968) figured as *P. olenoides* differs from the species as revised here because the eyes are further back and further from the glabella, and the postocular cheeks are narrower with a more transverse posterolateral margin. It may be referable to *Leptoplastides*.

Family BOHEMILLIDAE Barrande, 1872
Genus BOHEMILLA Barrande, 1872

Type species. By monotypy, *Bohemilla stupenda* Barrande, 1872.

Bohemilla (*Bohemilla*) sp.

Plate 68, figs. 4 and 7; text-fig. 4C

Material. One small fragmentary cranidium, associated with two free cheeks and some thoracic fragments (RX 316A, B) from river Calder, Loc. 1.

EXPLANATION OF PLATE 68

Figs. 1–3. *Prospectatrix brevior* sp. nov. 1, RX 916, Loc. 1, holotype, latex cast of external mould, ×4. 2, RX 928, Loc. 2, cranidium; note faint glabellar furrows, ×4. 3, RX 1542, Loc. 1, free cheek, latex cast of external mould, ×4.

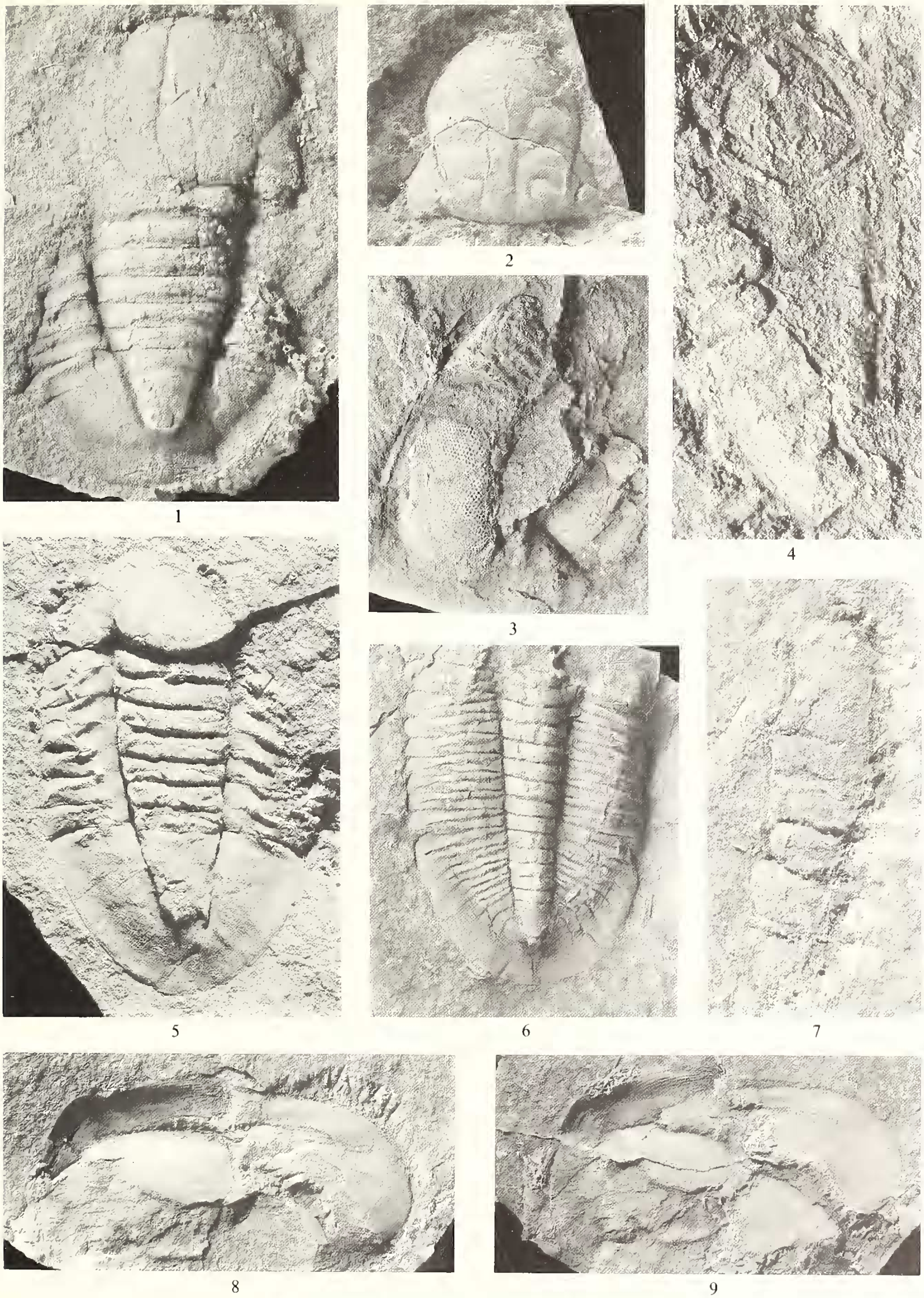
Figs. 4 and 7. *Bohemilla* (*Bohemilla*) sp. RX 316B, Loc. 1. 4, right free cheek with fragment of left cheek. 7, cranidium with fragment of thoracic axis; both ×12. For reconstruction, see text-fig. 4C.

Fig. 5. Nileid sp. 1. RX 317, Loc. 1, ×3.

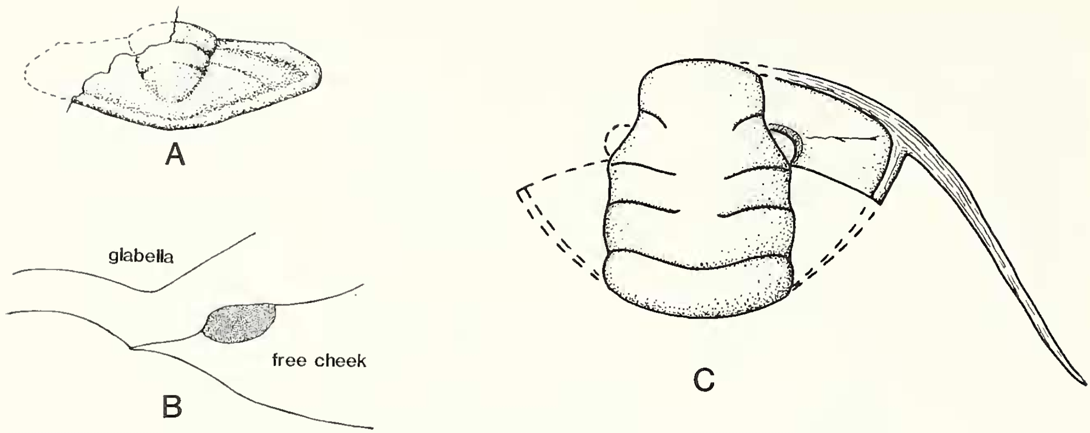
Fig. 6. *Niobina davidis* Lake, 1946. RX 259, Loc. 1, latex cast of thorax and pygidium (figured by Molyneux and Rushton 1985, fig. 1.11), ×2.

Figs. 8 and 9. Nileid sp. 2. RX 521 and 522, Loc. 1, fragmentary cranidium and free cheeks, internal mould and latex cast of counterpart, ×2.

PLATE 68



RUSHTON, *Prospectatrix*, *Bohemilla* (*Bohemilla*), *Niobina*, nileid



TEXT-FIG. 4. A, *Pareuloma expansum* sp. nov., RX 520, reconstruction of pygidium (see Pl. 66, fig. 14), ×6. B, *Peltocare olenoides* (Salter, 1866), RX 517 (sketch), oblique anterolateral view of cephalon to show holochroal eye (see Pl. 67, fig. 2). C, *Bohemilla* (*Bohemilla*) sp., based on RX 316B, reconstruction of cephalon (Pl. 68, figs. 4 and 7).

Discussion. The cranidial fragment shows the S1 furrow to be simple and not hooked proximally as in *B. stupenda* and other Bohemian species (Marek 1966). The glabella is contracted in front of S2, but gradually, and not abruptly as in *B. pragensis* Marek (1966, pl. 2, figs. 10 and 11) or *B. tridens* Rushton and Hughes (1981, pl. 5, figs. 11, 15, 16). Only a fragment of the postocular cheek is visible, but it shows that the base of the border furrow is directed unusually transversely for a *Bohemilla*, making an angle of 50°–60° to the sagittal line. The free cheek associated with the cranidium has an acute inner spine angle; the ocular incisure shows clearly that the eye was short. If it extended forwards from S2, as in other species of *Bohemilla*, it did not reach as far forward as S3.

The free cheek also shows that the postocular suture was comparatively long (about three times as long as the ocular incisure). In other species the postocular suture is no longer than the ocular incisure (Marek 1966, pl. 1, fig. 8, pl. 2, fig. 4; Rushton and Hughes 1981, pl. 5, fig. 12).

This fragmentary specimen is the oldest described bohemillid. Compared with the upper Arenig species *B.* (*Fenniops*) *sabulon* Fortey and Owens (1987, p. 129) the present form has a contracted glabella, which is considered a comparatively advanced character, but shares the more primitive form of the glabellar furrows and postocular cheeks.

Family ASAPHIDAE Burmeister, 1843
Subfamily NIOBINAE Jaanusson, 1959
Genus NIOBINA Lake, 1946

Type species. By original designation, *Niobina davidis* Lake, 1946.

Niobina davidis Lake, 1946

Plate 68, fig. 6

1946 *Niobina davidis* Lake, p. 334, pl. 47, figs. 1–5 (synonymy).
1985 *Niobina davidis* Lake (?); Molyneux and Rushton, p. 126, fig. 1.11.

Material. Thorax and pygidium in counterpart (RX 258, 259), and two poorly preserved free cheeks (RX 289, 292). All from river Calder, Loc. 1.

Discussion. The figured thorax and pygidium agree in all details with Lake's figured specimens and with other material from the upper Tremadoc series in North Wales. The pygidium has about eight axial rings, and about seven pairs of pleurae marked by interpleural grooves. It thereby differs from *N. taurina* Harrington and Leanza (1957, p. 180, fig. 91.1) from the lower Tremadoc of Argentina which has twelve axial rings and eleven pairs of pleural furrows. Tjernvik's *Niobina* sp. (1956, p. 234, pl. 5, fig. 17), from the *Apatokephalus serratus* Biozone (upper Tremadoc) of Sweden has about ten axial rings and nine or ten pairs of pleural furrows. The free cheeks collected from the river Calder locality are imperfect but show the blunt genal angle and the anterior extension of the doublure cut off by the median suture. No example of the cranidium has been collected, so although the pygidium agrees precisely with Lake's *N. davidis*, there remains an element of doubt about specific determination.

N. davidis is recorded from the *Shumardia pusilla* Biozone and *Angelina sedgwickii* Biozone in the upper Tremadoc Series in North Wales, and in the US National Museum there is a specimen from the Upper Tremadoc of New Brunswick (Dr R. A. Fortey, pers. comm.).

Family NILEIDAE Angelin, 1854
Nileid sp. 1

Plate 68, fig. 5

Material. One axial shield lacking the anterior part of the cranidium (RX 317), from river Calder, Loc. 1.

Description. Postocular facial suture practically straight and directed outwards and backwards at about 30° to sagittal line. Postocular cheek about half as wide as occipital ring. Thorax of seven segments: anterior pleura two-thirds width of axis; posterior pleura as wide as axis. Pleural geniculation close to axial furrow throughout. Pygidium semi-elliptical, length two-thirds of width. Axis occupies one-third of width and 0·6 of length of pygidium and lacks ring furrows. Pleural regions unfurrowed. Doublure wide, extending inwards to fulcral line.

Discussion. The present specimen may be referable to *Barrandia* M'Coy, as discussed by Hughes (1979, p. 154), but as the thorax has only seven segments and the pygidium has a better-marked flattened marginal rim, I hesitate to include this form in *Barrandia*. The postocular suture resembles that of certain other nileids such as *Peraspis omega* Fortey (1975, pl. 20, fig. 1) from the Arenig Series in Spitsbergen, though that species has narrower postocular cheeks. The poorly known *Hemibarrandia holoubkovensis* Růžička (1926, pl. 2, figs. 5 and 6), from the lower Tremadoc of Bohemia, differs from the present form in having a more transverse pygidium with a narrower doublure (Růžička 1931, pl. 1, fig. 8). As the cranidium is fragmentary, closer comparison is impossible, but the present form is clearly distinct from most nileids (e.g. *Nileus*, *Symphysurus*, *Platypeltoides*) in the length and straightness of the postocular suture. The pygidium is peculiar in being elongate and semi-elliptical.

Nileid sp. 2

Plate 68, figs. 8 and 9

Material. Fragmentary cranidium and conjoined free cheeks (RX 521, 522), from river Calder, Loc. 1.

Discussion. The long postocular suture, curved outwards and backwards, clearly distinguishes this form from Nileid sp. 1, above. The form of the free cheek (Pl. 68, fig. 9) shows that the eye was comparatively far forward and rather small compared with most nileid genera. *Illaenopsis* Salter has very small eyes but in most species the glabella is fairly well marked where it expands at its forward end, e.g. *I. thomsoni* Salter (Whittard 1961, pl. 31, fig. 3); *I. gaspensis* (Rasetti 1954, pl. 60, figs. 9 and 10); *I. griffei* Courtessole and Pillet (1975, pl. 27, figs. 5–11 and presumably also pl. 26, fig. 21). There is no sign of this expansion in the present fragment (Pl. 68, fig. 8). In the early Tremadoc species *Psilocephalinella innotata* (Salter) the axial furrow is nearly effaced (Lake

1942, pl. 44, figs. 2–7), but the eye is further back than in the present form, so that the free cheek is of a different shape.

Family CYCLOPYGIDAE Raymond, 1925
Genus PROSPECTATRIX Fortey, 1981

Type species. By original designation, *Cyclopyge genatenta* Stubblefield *in* Stubblefield and Bulman, 1927.

Prospectatrix brevior sp. nov.

Plate 68, figs. 1–3

Name. Latin, shorter (than the type), the thoracic axis having six rather than seven segments.

Material. Holotype, an axial shield in counterpart (RX 915, 916; Pl. 68, fig. 1) from river Calder, Loc. 1. Paratypes, a cranidium (RX 928) from Loc. 2, and a visual surface (RX 1542) from Loc. 1. One poorly preserved but nearly complete specimen (RX 2550), collected by Mr M. J. N. Cullen from Loc. 1, is thought to belong to this species.

Diagnosis. A species of *Prospectatrix* with relatively broad postocular cheeks and very narrow interocular cheeks. Thorax of six segments. Pygidial axis divided into three distinct rings and a terminal part.

Discussion. A full description is unnecessary here because this material resembles that of *P. genatenta*, as described by Stubblefield (*in* Stubblefield and Bulman 1927, p. 138) and redescribed by Fortey (1981, p. 611). Compared with *P. genatenta*, the cephalic axis and glabellar furrows of *P. brevior* have the same form (Pl. 68, fig. 2) and the postocular cheeks are of similar size (about 0·3 of the basal width of the cephalic axis). A significant difference lies in the reduced interocular cheeks, which in *P. brevior* constitute only a very narrow rim close to the glabella, whereas in *P. genatenta* the interocular cheek is about one-sixth as wide as the glabella. The visual surface appears to widen posteriorly, as in *P. genatenta* (Fortey 1981, pl. 1*c*). There are only six thoracic segments in *P. brevior*, whereas *P. genatenta* has seven. The pygidium is longer than that of *P. genatenta*, the axis has three rings and a terminal part, rather than two rings as in *P. genatenta*. The doublure in the two species is similar, with a median cusp extending forward to the tip of the pygidial axis. These differences—the reduction in the fixed cheeks and the reduction in number of thoracic segments, with a concomitant increase in the size of the pygidium—appear to be advances from more primitive character-states in *P. genatenta*, and *P. brevior* thus lies morphologically between *Prospectatrix* and other Cyclopygidae.

Fortey (1981, p. 612) suggested that *Pricyclopyge superciliata* Dean (1973, p. 314), from beds tentatively ascribed to the lower Arenig in Turkey (Dean 1973, p. 343), might be a species of *Prospectatrix*, and Fortey and Owens (1987, p. 176) subsequently compared a specimen of *Prospectatrix* from the Fennian (Upper Arenig) of South Wales with *Pricyclopyge superciliata*. The cranidium of *P. superciliata* (Dean 1973, pl. 6, fig. 6) resembles that of the new species, although the cephalic axis is shorter relative to its length. Compared with *Prospectatrix brevior*, *Pricyclopyge superciliata* has broader interocular cheeks, whereas the postocular cheeks are both narrower and shorter (exsag.), indicating that *P. superciliata* had larger eyes than *Prospectatrix brevior*.

A cranidium illustrated by Apollonov *et al*. (1984, pl. 23, fig. 11) may also be referable to *Prospectatrix*. It resembles *Pricyclopyge superciliata* rather than *Prospectatrix brevior* in its short, wide cephalic axis and small postocular cheeks.

Acknowledgements. I thank the many friends who helped with fossil collecting, especially Dr R. D. Hutchison who found some of the best specimens (text-fig. 3C; Pl. 68, figs. 1 and 2), and my colleagues, notably E. P. Smith and S. P. Tunnicliff, for assistance in the field. I thank Dr S. G. Molyneux (who initiated the study by finding the specimen in Pl. 68, fig. 6) and Dr R. A. Fortey for much helpful discussion. Sir James Stubblefield read the manuscript and offered helpful criticism. This paper is a contribution to the BGS Lake

District Regional Geological Survey, and is published by permission of the Director, British Geological Survey (NERC).

REFERENCES

ALLEN, P. M. and COOPER, D. C. 1986. The stratigraphy and composition of the Latterbarrow and Redmain sandstones, Lake District, England. *Geol. Jl*, **21,** 59–76.

ANGELIN, N. P. 1854. *Palaeontologia Scandinavica, Pars 1. Crustacea formationis transitionis*. Fasc. II, i–ix+21–92, pls. 25–41. Lund.

APOLLONOV, M. K. and CHUGAEVA, M. N. 1983. Pp. 66–90, pls. 7–10. *In* APOLLONOV, M. K., BANDALETOV, S. M. and IVSHIN, N. K. (eds.). *The Lower Paleozoic stratigraphy and palaeontology of Kazakhstan*, 176 pp., 39 pls. Acad. Sci. Kazakh SSR, 'NAUKA', Alma-Ata. [In Russian.]

—— —— and DUBININA, C. V. 1984. *Trilobites and conodonts from the Batyrbay Section (uppermost Cambrian–Lower Ordovician) in Malyi Karatau Range* (atlas of the palaeontological plates), 48 pp., 32 pls. Acad. Sci. Kazakh SSR, 'NAUKA', Alma-Ata. [In Russian.]

BALASHOVA, E. A. 1961. Some Tremadoc trilobites of the Aktyubin region. *Trudy geol. Inst. Acad. Nauk SSSR* [Moscow], **18,** 102–145, 4 pls. [In Russian.]

BARRANDE, J. 1872. *Systême Silurien du centre de la Boheme. lère partie. Recherches Paléontologiques, supplement au Vol. 1. Trilobites, Crustacés diverse et Poissons*, xxx+647 pp., 35 pls. Prague, Paris.

BILLINGS, E. 1861–1865. *Palaeozoic Fossils*, Vol. 1, 427 pp. Geological Survey of Canada, Montreal.

BRÖGGER, W. C. 1882. *Die silurichen Etagen 2 und 3 im Kristianiagebiet*, etc., viii+376 pp., 12 pls. Kristiana.

BURMEISTER, H. 1843. *Die Organisation der Trilobiten*, etc., xii+148 pp., 6 pls. Berlin.

CALLAWAY, C. 1877. On a new area of Upper Cambrian rocks in south Shropshire, with a description of a new fauna. *Q. Jl geol. Soc. Lond.* **33,** 652–672, pl. 24.

CAPERA, J. C., COURTESSOLE, R. and PILLET, J. 1978. Contribution à l'étude de l'Ordovicien inférieur de la Montagne Noire. Biostratigraphie et revision des Agnostida. *Annls Soc. géol. N.* **98,** 67–88, pls. 5–7.

CHANG WENT'ANG and FAN CHIASUNG. 1960. Pp. 83–147, pls. 1–10. *In* YIN TSANHSUN (ed.). *Geological gazetteer of the Chi-Lien Mountains*, **4** (1, *Palaeontological descriptions . . .*). Science Press, Beijing. [In Chinese.]

COCKS, L. R. M. and FORTEY, R. A. 1982. Faunal evidence for oceanic separations in the Palaeozoic of Britain. *Jl geol. Soc. Lond.* **139,** 465–478.

COURTESSOLE, R. and PILLET, J. 1975. Contribution à l'étude des faunes trilobitique de l'Ordovicien inférieur de la Montagne Noire. Les Eulominae et les Nileidae. *Annls Soc. géol. N.* **95,** 251–271, pls. 24–27.

COWIE, J. W., RUSHTON, A. W. A. and STUBBLEFIELD, C. J. 1972. A correlation of the Cambrian rocks in the British Isles. *Spec. Rep. geol. Soc. Lond.* **2,** 42 pp.

CURTIS, M. L. K. 1968. The Tremadoc rocks of the Tortworth Inlier, Gloucestershire. *Proc. Geol. Ass.* **79,** 349–362.

DEAN, W. T. 1966. The Lower Ordovician stratigraphy and trilobites of the Landeyran Valley and the neighbouring district of the Montagne Noire, south-west France. *Bull. Br. Mus. nat. Hist.* (Geol.), **12,** 245–353, 21 pls.

—— 1973. The Lower Palaeozoic stratigraphy and faunas of the Taurus Mountains near Beyşehir, Turkey. III. The trilobites of the Sobova Formation (Lower Ordovician). Ibid. **24,** 279–348, 12 pls.

ELLES, G. L. 1898. The graptolite-fauna of the Skiddaw Slates. *Q. Jl geol. Soc. Lond.* **54,** 463–539.

ERGALIEV, G. CH. 1983. Pp. 35–66, pls. 1–6. *In* APOLLONOV, M. K., BANDALETOV, S. M. and IVSHIN, N. K. (eds.). *The Lower Paleozoic stratigraphy and palaeontology of Kazakhstan*, 176 pp., 39 pls. Acad. Sci. Kazakh SSR, 'NAUKA', Alma-Ata. [In Russian.]

FORTEY, R. A. 1975. The Ordovician trilobites of Spitsbergen. II. Asaphidae, Nileidae, Raphiophoridae and Telephinidae of the Valhallfonna Formation. *Skr. norsk Polarinst.* **162,** 207 pp., 42 pls.

—— 1980. The Ordovician trilobites of Spitsbergen. III. Remaining trilobites of the Valhallfonna Formation. Ibid. **171,** 163 pp., 25 pls.

—— 1981. *Prospectatrix genatenta* (Stubblefield) and the trilobite superfamily Cyclopygacea. *Geol. Mag.* **118,** 603–614, 1 pl.

—— 1984. Global earlier Ordovician transgressions and regressions and their biological implications, 37–50. *In* BRUTON, D. L. (ed.). Aspects of the Ordovician System. *Palaeont. Contr. Univ. Oslo*, **295.**

—— and COCKS, L. R. M. 1986. Marginal faunal belts and their structural implications, with examples from the Lower Palaeozoic. *Jl geol. Soc. Lond.* **143,** 151–160.

FORTEY, R. A., LANDING, E. and SKEVINGTON, D. 1982. Cambrian–Ordovician boundary sections in the Cow Head Group, western Newfoundland, 95–129. *In* BASSETT, M. G. and DEAN, W. T. (eds.). The Cambrian–Ordovician boundary: sections, fossil distributions, and correlations. *Geol. Ser. nat. Mus. Wales*, **3,** 227 pp.

—— and OWENS, R. M. 1978. Early Ordovician (Arenig) stratigraphy and faunas of the Carmarthen district, south-west Wales. *Bull. Br. Mus. nat. Hist.* (Geol.), **30,** 225–294, 11 pls.

—— —— 1987. The Arenig Series in South Wales. Ibid. **41,** 69–307, 146 figs.

—— and RUSHTON, A. W. A. 1980. *Acanthopleurella* Groom 1902: origin and life-habits of a miniature trilobite. Ibid. **33,** 79–89.

HARRINGTON, H. J. 1938. Sobre las faunas del Ordoviciano Inferior del Norte Argentino. *Revta Mus. La Plata*, Seccion. Paleont., NS, **1,** 109–289, pls. 1–14.

—— and LEANZA, A. 1957. Ordovician trilobites of Argentina. *Spec. Publs Dep. Geol. Univ. Kansas*, **1,** 276 pp., 140 figs.

HAWLE, I. and CORDA, A. J. C. 1847. *Prodrom einer Monographie der böhmischen Trilobiten*, 176 pp., 7 pls. Prague.

HENNINGSMOEN, G. 1957. The trilobite family Olenidae. *Skr. norske Vidensk.-Akad. mat.-nat. Kl.* **1957,** no. 1, 303 pp., 31 pls.

—— 1959. Rare Tremadocian trilobites from Norway. *Norsk geol. Tidsskr.* **39,** 153–174, 2 pls.

HOWELL, B. F. 1935. Cambrian and Ordovician trilobites from Herault, southern France. *Jl Paleont.* **9,** 222–238, pls. 22 and 23.

HUGHES, C. P. 1979. The Ordovician trilobite faunas of the Builth–Llandrindod Inlier, central Wales. Part III. *Bull. Br. Mus. nat. Hist.* (Geol.), **32,** 109–181.

JAANUSSON, V. 1959. *In* HARRINGTON, H. J. *et al.* Trilobita, 38–540. *In* MOORE, R. C. (ed.). *Treatise on invertebrate paleontology, Part O, Arthropoda 1*, xix + 560 pp. Geological Society of America and University of Kansas Press, New York and Lawrence, Kansas.

JACKSON, D. E. 1962. Graptolite zones in the Skiddaw Group in Cumberland, England. *Jl Paleont.* **36,** 300–313.

JAEKEL, O. 1909. Über die Agnostiden. *Z. dt. geol. Ges.* **61,** 380–401.

KOBAYASHI, T. 1955. The Ordovician fossils from the McKay Group in British Columbia, western Canada, with a note on the early Ordovician palaeogeography. *J. Fac. Sci. Tokyo Univ.* sect. 2, **9** (3), 355–493, pls. 1–9.

LAKE P. 1906–1946. British Cambrian trilobites. *Palaeontogr. Soc.* [*Monogr.*], Part 1 (1906), 1–28, pls. 1 and 2; Part 2 (1907), 29–48, pls. 3 and 4; Part 4 (1913), 65–88, pls. 7–10; Part 5 (1919), 89–120, pls. 11–14; Part 13 (1942), 307–332, pls. 44–46; Part 14 (1946), 333–350, pl. 47.

LAZARENKO, N. P. 1966. Biostratigraphy and some new trilobites from the Upper Cambrian of the Olenek Uplift and the Kharaulakh Mountains. *Uchen. Zap. nauchno-issled. Inst. geol. arkt., Paleont. Biostratigr.* **11,** 33–78, 8 pls. [In Russian.]

LU YAN-HAO and LIN HUAN-LING. 1984. Late late Cambrian and earliest Ordovician trilobites of Jiangshan–Changshan area, Zhejiang, 45–144, 19 pls. In *Stratigraphy and palaeontology of systemic boundaries in China. Cambrian–Ordovician boundary* (*1*). Nanjing Inst. Geol. Palaeont., Acad. Sinica.

—— and QIAN YI-YUAN. 1977. *In* ZHOU TIEN-MEI *et al.* (eds.). Trilobita, 104–266, pls. 33–81. *Atlas of fossils of central and south China. 1. Lower Palaeozoic.* Geological Publishing House, Beijing. [In Chinese.]

—— —— 1983. Cambro–Ordovician trilobites from eastern Guizhou. *Palaeont. Cathay.* **1,** 1–105, 12 pls.

—— ZHOU ZHIYI and ZHOU ZHIQIANG. 1981. Cambrian–Ordovician boundary and their related trilobites in the Hangula region, W. Nei Monggol. *Bull. chin. Acad. geol. Sci.*, ser. 10, **2** (1), 1–22, pls. 1–3. [In Chinese, English summary.]

LUDVIGSEN, R. 1982. Upper Cambrian and Lower Ordovician trilobite biostratigraphy of the Rabbitkettle Formation, western District of Mackenzie. *Contr. Life Sci. Div. R. Ont. Mus.* **134,** 188 pp., 70 figs.

MAREK, L. 1966. The trilobite family Bohemillacea Barrande, 1872 in the Ordovician of Bohemia. *Čas. národ. Mus.* **135,** 143–153, pls. 1 and 2 (= 11 and 12).

MAXIMOVA, Z. A. [MAKSIMOVA]. 1962. Biostratigraphy of the Palaeozoic of the Siberian Platform, part 5. Trilobites of the Ordovician and Silurian of the Siberian Platform. *Trudý vses. nauchno-issled. geol. Inst.* NS, **76,** 215 pp., 18 pls. [In Russian.]

MOBERG, J. C. 1900. Nya bidrag till utredning af frågan om gränsen mallan undersilur och kambrium. *Geol. För. Stockh. Förh. 22*, 523–540, pl. 14.

—— and MÖLLER, H. 1898. Om Acerocarezonen. Ibid. **20,** 198–290, pls. 10–14.

MOLYNEUX, S. G. and RUSHTON, A. W. A. 1985. Discovery of Tremadoc rocks in the Lake District. *Proc. Yorks. geol. Soc.* **45,** 123–127 (dated 1984).

MORRIS, S. F. 1988. A review of British trilobites, including a synoptic revision of Salter's monograph. *Palaeontogr. Soc.* [*Monogr.*], 316 pp.

NIKOLAISEN, F. and HENNINGSMOEN, G. 1985. Upper Cambrian and lower Tremadoc olenid trilobites from the Digermul Peninsula, Finnmark, northern Norway. *Bull. Norsk geol. Unders.* **400,** 1–49, 18 figs.

OWEN, A. W. 1985. Trilobite abnormalities. *Trans. R. Soc. Edinb.*, Earth Sci., **76,** 255–272.

PALMER, A. R. 1968. Cambrian trilobites of east-central Alaska. *Prof. Pap. US geol. Surv.* **559-B,** 115 pp., 15 pls.

PENG SANCHI. 1984. Cambrian–Ordovician boundary in the Cili Taoyuan border area, northwestern Hunan with descriptions of relative trilobites, 285–405, 18 pls. In *Stratigraphy and palaeontology of systemic boundaries in China. Cambrian–Ordovician boundary* (*1*). Nanjing Inst. Geol. Palaeont., Acad. Sinica.

RASETTI, F. 1954. Early Ordovician trilobite faunules from Quebec and Newfoundland. *Jl Paleont.* **28,** 581–587, pls. 60 and 61.

RAYMOND, P. E. 1925. Some trilobites of the lower Middle Ordovician of eastern North America. *Bull. Mus. comp. Zool. Harv.* **67,** 1–180, pls. 1–10.

ROBISON, R. A. 1982. Some Middle Cambrian agnostoid trilobites from western North America. *Jl Paleont.* **56,** 132–160.

—— and PANTOJA-ALOR, J. 1968. Tremadocian trilobites from the Nochixtlán region, Oaxaca, Mexico. Ibid. **42,** 767–800, pls. 97–104.

ROSE, W. C. C. 1954. The sequence and structure of the Skiddaw Slates in the Keswick–Buttermere area. *Proc. Geol. Ass.* **65,** 403–406.

ROSOVA, A. V. [ROZOVA]. 1963. Biostratigraphic scheme of upper parts of Middle Cambrian and of Upper Cambrian of north-western part of Siberian Platform, and new Upper Cambrian trilobites of the River Kulyumbe area. *Geol. Geofiz. Novosibirsk*, **9,** 1–19, pls. 1 and 2. [In Russian.]

—— 1968. Biostratigraphy and trilobites of the Upper Cambrian and Lower Ordovician of the northwestern Siberian Platform. *Trudy Inst. Geol. Geofiz. sib. Otd.* **36,** 196 pp., 17 pls. [In Russian.]

RUSHTON, A. W. A. 1982. The biostratigraphy and correlation of the Merioneth–Tremadoc Series boundary in North Wales, 41–59. *In* BASSETT, M. G. and DEAN, W. T. (eds.). The Cambrian–Ordovician boundary: sections, fossil distributions, and correlations. *Geol. Ser. nat. Mus. Wales*, **3,** 227 pp.

—— 1985. A Lancefieldian graptolite from the Lake District. *Geol. Mag.* **122,** 329–333.

—— and HUGHES, C. P. 1981. The Ordovician trilobite fauna of the Great Paxton Borehole, Cambridgeshire. **118,** 623–646, 6 pls.

RŮŽIČKA, R. 1926. Faune des couches à Euloma du gisement ferrugineux près de Holoubkov (à Ouzky). *Bull. int. Acad. Sci. Bohême*, for 1926, 1–24, pls. 1–3.

—— 1931. Supplement à la faune des couches à Euloma du gisement metallifère près de Holoubkov (à Ouzky). *Věst. st. geol. Úst. čsl. Repub.* **7,** číslo 4–5, 1–20, pl. 1 (18).

SALTER, J. W. 1866. On the fossils of North Wales. Appendix, pp. 239–363. *In* RAMSAY, A. C. (ed.). The geology of North Wales. *Mem. geol. Surv. Gt Br.* **3,** viii+381 pp., 28 pls.

SCOTESE, C. R., BAMBACH, R. K., BARTON, C., VAN DER VOO, R. and ZIEGLER, A. M. 1979. Paleozoic base maps. *Jl Geol.* **87,** 217–277.

SDZUY, K. 1955. Die Fauna der Leimitz-Schiefer (Tremadoc). *Abh. senckenb. naturforsch. Ges.* **492,** 1–74, pls. 1–8.

—— 1958. Fossilien aus den Tremadoc des Montagne Noire. *Senckenberg. leth.* **39,** 255–258, pls. 1–3.

SHACKLETON, E. H. 1975. *Geological excursions in Lakeland*, 127 pp. Dalesman, Nelson.

SHAW, A. B. 1951. The paleontology of northwestern Vermont. 1. New Upper Cambrian trilobites. *Jl Paleont.* **25,** 97–114, pls. 21–24.

SHERGOLD, J. H. 1972. Late Upper Cambrian trilobites from the Gola Beds, western Queensland. *Bull. Bur. Miner. Resour. Geol. Geophys. Aust.* **112,** 127 pp., 19 pls.

—— 1975. Late Cambrian and early Ordovician trilobites from the Burke River structural belt, western Queensland. Ibid. **153,** 251 pp., 58 pls. (2 vols.).

—— 1980. Late Cambrian trilobites from the Chatsworth Limestone, western Queensland. Ibid. **186,** 111 pp., 35 pls.

—— and SDZUY, K. 1984. Cambrian and early Tremadoc trilobites from Sultan Dag, central Turkey. *Senckenberg. leth.* **65,** 51–135, pls. 1–8.

STORMER, L. 1940. Early descriptions of Norwegian trilobites. The type specimens of C. Boeck, M. Sars and M. Esmark. *Norsk geol. Tidsskr.* **20,** 113–151, 3 pls.

STUBBLEFIELD, C. J. 1926. Notes on the development of a trilobite, *Shumardia pusilla* (Sars). *Jl Linn. Soc., Zool.* **36,** 345–372, pls. 14–16.

STUBBLEFIELD, C. J. and BULMAN, O. M. B. 1927. The Shineton Shales of the Wrekin district. *Q. Jl geol. Soc. Lond.* **83,** 96–146, pls. 3–5.

TJERNVIK, T. E. 1956. On the early Ordovician of Sweden. *Bull. geol. Instn Univ. Uppsala*, **36,** 109–284, 11 pls.

WHITTARD, W. F. 1961. The Ordovician trilobites of the Shelve Inlier, west Shropshire. *Palaeontogr. Soc.* [*Monogr.*], Part 6, 197–228, pls. 26–33.

WHITTINGTON, H. B. and HUGHES, C. P. 1974. Geography and faunal provinces in the Tremadoc epoch. *Spec. Publs Soc. econ. Paleont. Miner.* **21,** 203–218.

WIMAN, C. 1902. Studien über das Nordbaltische Silurgebiet. *Bull. geol. Instn Univ. Uppsala*, **6,** 10–76, 4 pls., map.

WINSTON, D. and NICHOLLS, H. 1967. Late Cambrian and early Ordovician faunas from the Wilberns Formation of central Texas. *Jl Paleont.* **41,** 66–96, pls. 9–13.

XIANG LI-WEN and ZHANG TAI-RONG. 1984. Tremadocian trilobites from western part of northern Tianshan, Xinjiang. *Acta palaeont. sin.* **23,** 399–410, 3 pls. [In Chinese, English summary.]

—— —— 1985. Stratigraphy and trilobite faunas of the Cambrian in the western part of northern Tianshan, Xinjiang. *People's Republic of China, Ministry of Geology and Mineral Resources. Geological Memoirs*, ser. 2, **4,** ix + 243 pp., 52 pls. [In Chinese, English summary.]

YIN GONG-ZHENG and LEE SHAN-JI. 1978. Trilobita, 385–594, pls. 144–192. *Atlas of fossils of southwest China. Guizhou province. 1. Cambrian to Devonian.* Geological Publishing House, Beijing. [In Chinese.]

ZHOU ZHI-YI and ZHANG JIN-LIN. 1984. Uppermost Cambrian and lowest Ordovician trilobites of north and north-east China, 63–163, 29 pls. In *Stratigraphy and palaeontology of systemic boundaries in China. Cambrian–Ordovician Boundary (2).* Nanjing Inst. Geol. Palaeont., Acad., Sinica.

A. W. A. RUSHTON
British Geological Survey
Keyworth
Nottingham NG12 5GG

Typescript received 29 May 1987
Revised typescript received 7 September 1987